<CT>**Using big data to map the relationship between time perspectives and economic outputs**

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Abstract: Recent studies have shown that population-level time perspectives can be approximated using "big data" on search engine queries, and that these indices, in turn, predict the per-capita GDP of countries. Although these findings seem to support Baumard's suggestion that affluence makes people more future-oriented, they also reveal a more complex relationship between time-perspectives and economic outputs.

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Baumard argues that affluence leads to people becoming more future-oriented, which in turn, allows for greater innovation efforts. This is an intriguing hypothesis, but also one that requires the right kinds of population-level data in order to test it. Fortunately, researchers can now use search engine data to map human behaviors and derive proxies of human cognition at the aggregate level (Moat et al. 2014; 2016). The growing availability of data on the Web offers novel ways to estimate the characteristics of time preferences at the population level. For example, according to one prominent decision making theory (Olivola & Chater 2017; Stewart et al. 2006), the curvature of the delay discount function (i.e., the rate at which delayed rewards are devalued compared to immediate rewards) is determined by the relative frequencies with which people are exposed to delays of various lengths, and this, in turn, can be estimated from the contents of the Web. Specifically, researchers have used the frequencies of mentions of various delay lengths (e.g., "1 day," "2 days," …, "1 week," "2 weeks," etc.) to estimate this exposure, and shown that the resulting distribution predicts the shape of one of the most empirically established delay discount functions (Olivola & Chater 2017; Stewart et al. 2006). One could, in principle, carry out separate searches of this sort for different countries (e.g., by counting the relative mentions of delay lengths in the most prominent news sources within each country) to estimate their (aggregate) discount functions and see whether this predicts their levels of innovation and economic performance.

In fact, with our colleagues, we have proposed novel proxies of aggregate (population-level) time perspectives, which can be estimated for each country (Noguchi et al. 2014; Preis et al. 2012). Specifically, we used Google Trends to

calculate the relative volume of searches for future years (e.g., searching for "2020" in the year 2019), past years (e.g., searching for "2018" in the year 2019), and present years (e.g., searching for "2019" in 2019), within each country. The ratios of these search volumes provide indices of the extent to which the online search behavior of citizens in a given country is focused on the future relative to the past (Preis et al. 2012), as well as the future relative to the present and the past relative to the present (Noguchi et al. 2014). These indices can be obtained for many countries, and for a number of different years, going back more than a decade. As such, they constitute useful approximations of aggregate time perspectives – the extent to which people are focused on the past, present, and future – for each country.

It turns out these time perspective indices are strongly correlated with gross domestic product (GDP) per capita – a key measure of a country's economic output. Preis et al. (2012) calculated the ratio of future-year searches to past-year searches for 45 different countries and found that the resulting "future orientation" values predicted per capita GDP (r = .78). Noguchi et al. (2014) examined four other indices: the ratio of future-year searches to present-year searches ("future focus"), the ratio of past-year searches to present-year searches ("past focus"), the deceleration in the volume of past-year searches ("past time-horizon"), and the acceleration in the volume of future-year searches ("future time-horizon"). They found that three of these four indices (future focus, past focus, and past time-horizon) were significant predictors of country per capita GDP. Specifically, higher future focus and past time-horizon values, as well as lower past focus values, were all independently associated with higher per capita GDP. In sum, this work shows that one can generate indices of

population-level time perspectives using “big data” from activity on the Web, and that the resulting indices are strongly correlated with economic output.

These findings seem to support Baumard’s suggestion that affluence makes people more future-oriented. However, these studies also reveal that the relationship between time perspectives and economic outputs is more complex than he suggests. For example, the extent to which a population is focused on the past (vs. present) and the extent to which it is focused on the future (vs. present) both *independently* predict economic output, albeit in opposite directions (Noguchi et al. 2014). Moreover, the rate at which a population shifts its focus from the past to the present over time (past time-horizon) also positively predicts economic output (Noguchi et al. 2014). Finally, we echo Baumard’s caution against drawing strong conclusions regarding the direction of the relationship between future-orientation (or other time focus indices) and economic performance without appropriate, additional evidence, as each could plausibly affect the other: greater affluence could lead to people becoming more future-oriented; however, a greater focus on the future could also lead to greater affluence, by helping people consider the future consequences of their decisions (Read et al. 2017), and thus maximize their long-term wealth.

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